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| <p>(54) Title: PYRAZOLOPYRIMIDINONES FOR THE TREATMENT OF IMPOTENCE</p> <p>(57) Abstract</p> <p>The use of a compound of formula (I) wherein R<sup>1</sup> is H; C<sub>1</sub>-C<sub>3</sub> alkyl; C<sub>1</sub>-C<sub>3</sub> perfluoroalkyl; or C<sub>3</sub>-C<sub>5</sub> cycloalkyl; R<sup>2</sup> is H; optionally substituted C<sub>1</sub>-C<sub>6</sub> alkyl; C<sub>1</sub>-C<sub>3</sub> perfluoroalkyl; or C<sub>3</sub>-C<sub>6</sub> cycloalkyl; R<sup>3</sup> is optionally substituted C<sub>1</sub>-C<sub>6</sub> alkyl; C<sub>1</sub>-C<sub>6</sub> perfluoroalkyl; C<sub>3</sub>-C<sub>5</sub> cycloalkyl; C<sub>3</sub>-C<sub>6</sub> alkenyl; or C<sub>3</sub>-C<sub>6</sub> alkynyl; R<sup>4</sup> is optionally substituted C<sub>1</sub>-C<sub>4</sub> alkyl, C<sub>2</sub>-C<sub>4</sub> alkenyl, C<sub>2</sub>-C<sub>4</sub> alkanoyl, (hydroxy)C<sub>2</sub>-C<sub>4</sub> alkyl or (C<sub>2</sub>-C<sub>3</sub> alkoxy)C<sub>1</sub>-C<sub>2</sub> alkyl; CONR<sup>5</sup>R<sup>6</sup>; CO<sub>2</sub>R<sup>7</sup>; halo; NR<sup>5</sup>R<sup>6</sup>; NHSO<sub>2</sub>NR<sup>5</sup>R<sup>6</sup>; NHSO<sub>2</sub>R<sup>8</sup>; SO<sub>2</sub>NR<sup>9</sup>R<sup>10</sup>; or phenyl, pyridyl, pyrimidinyl, imidazolyl, oxazolyl, thiazolyl, thienyl or triazolyl any of which is optionally substituted with methyl; R<sup>5</sup> and R<sup>6</sup> are each independently H or C<sub>1</sub>-C<sub>4</sub> alkyl, or together with the nitrogen atom to which they are attached form an optionally substituted pyrrolidinyl, piperidino, morpholino, 4-N(R<sup>11</sup>)-piperazinyl or imidazolyl group; R<sup>7</sup> is H or C<sub>1</sub>-C<sub>4</sub> alkyl; R<sup>8</sup> is optionally substituted C<sub>1</sub>-C<sub>3</sub> alkyl; R<sup>9</sup> and R<sup>10</sup> together with the nitrogen atom to which they are attached form an optionally substituted pyrrolidinyl, piperidino, morpholino or 4-N(R<sup>12</sup>)-piperazinyl group; R<sup>11</sup> is H; optionally substituted C<sub>1</sub>-C<sub>3</sub> alkyl; (hydroxy)C<sub>2</sub>-C<sub>3</sub> alkyl; or C<sub>1</sub>-C<sub>4</sub> alkanoyl; R<sup>12</sup> is H; optionally substituted C<sub>1</sub>-C<sub>6</sub> alkyl; CONR<sup>13</sup>R<sup>14</sup>; CSNR<sup>13</sup>R<sup>14</sup>; or C(NH)NR<sup>13</sup>R<sup>14</sup>; and R<sup>13</sup> and R<sup>14</sup> are each independently H; C<sub>1</sub>-C<sub>4</sub> alkyl; or substituted C<sub>2</sub>-C<sub>4</sub> alkyl; or a pharmaceutically acceptable salt thereof, or a pharmaceutical composition containing either entity, for the manufacture of a medicament for the curative or prophylactic treatment of erectile dysfunction in a male animal, including man; a pharmaceutical composition for said treatment; and a method of said treatment of said male animal with said pharmaceutical composition or with said either entity.</p> <div data-bbox="909 1197 1331 1470"> <p style="text-align: right;">(I)</p> </div> |           |  |

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PYRAZOLOPYRIMIDINONES FOR THE TREATMENT OF IMPOTENCE

This invention relates to the use of a series of pyrazolo[4,3-d]pyrimidin-7-ones for the treatment of impotence.

Impotence can be defined literally as a lack of power, in the male, to copulate and may involve an inability to achieve penile erection or ejaculation, or both. More specifically, erectile impotence or dysfunction may be defined as an inability to obtain or sustain an erection adequate for intercourse. Its prevalence is claimed to be between 2 and 7% of the human male population, increasing with age, up to 50 years, and between 18 and 75% between 55 and 80 years of age. In the USA alone, for example, it has been estimated that there are up to 10 million impotent males, with the majority suffering from problems of organic rather than of psychogenic origin.

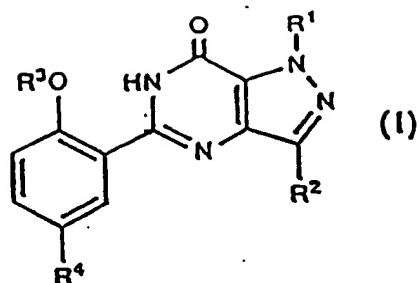
Reports of well-controlled clinical trials in man are few and the efficacy of orally administered drugs is low. Although many different drugs have been shown to induce penile erection, they are only effective after direct injection into the penis, e.g. intraurethrally or intracavernosally (i.c.), and are not approved for erectile dysfunction. Current medical treatment is based on the i.c. injection of vasoactive substances and good results have been claimed with phenoxybenzamine, phentolamine, papaverine and prostaglandin E<sub>1</sub>, either alone or in combination; however, pain, priapism and fibrosis of the penis are associated with the i.c. administration of some of these agents. Potassium channel openers (KCO) and vasoactive intestinal polypeptide (VIP) have also been shown to be active i.c., but cost and stability issues could limit development of the latter. An alternative to the i.c. route is the use of glyceryl trinitrate (GTN) patches applied to the penis, which has been

shown to be effective but produces side-effects in both patient and partner.

As a general alternative to pharmacological intervention, a variety of penile prostheses has been used to assist achievement of an erection. The short term success rate is good, but problems with infection and ischaemia, especially in diabetic men, make this type of treatment a final option rather than first-line therapy.

The compounds of the invention are potent inhibitors of cyclic guanosine 3',5'-monophosphate phosphodiesterases (cGMP PDEs) in contrast to their inhibition of cyclic adenosine 3',5'-monophosphate phosphodiesterases (cAMP PDEs). This selective enzyme inhibition leads to elevated cGMP levels which, in turn, provides the basis for the utilities already disclosed for the said compounds in EP-A-0463756 and EP-A-0526004, namely in the treatment of stable, unstable and variant (Prinzmetal) angina, hypertension, pulmonary hypertension, congestive heart failure, atherosclerosis, conditions of reduced blood vessel patency e.g. post-percutaneous transluminal coronary angioplasty (post-PTCA), peripheral vascular disease, stroke, bronchitis, allergic asthma, chronic asthma, allergic rhinitis, glaucoma, and diseases characterised by disorders of gut motility, e.g. irritable bowel syndrome (IBS).

Unexpectedly, it has now been found that these disclosed compounds are useful in the treatment of erectile dysfunction. Furthermore the compounds may be administered orally, thereby obviating the disadvantages associated with i.c. administration. Thus the present invention concerns the use of a compound of formula (I):



wherein  $R^1$  is H;  $C_1$ - $C_3$  alkyl;  $C_1$ - $C_3$  perfluoroalkyl; or  $C_3$ - $C_6$  cycloalkyl;  
 $R^2$  is H;  $C_1$ - $C_6$  alkyl optionally substituted with  $C_3$ - $C_6$  cycloalkyl;  $C_1$ - $C_3$  perfluoroalkyl; or  $C_3$ - $C_6$  cycloalkyl;  
 $R^3$  is  $C_1$ - $C_6$  alkyl optionally substituted with  $C_3$ - $C_6$  cycloalkyl;  $C_1$ - $C_6$  perfluoroalkyl;  $C_3$ - $C_6$  cycloalkyl;  $C_3$ - $C_6$  alkenyl; or  $C_3$ - $C_6$  alkynyl;  
 $R^4$  is  $C_1$ - $C_4$  alkyl optionally substituted with OH,  $NR^5R^6$ , CN,  $CONR^5R^6$  or  $CO_2R^7$ ;  $C_2$ - $C_4$  alkenyl optionally substituted with CN,  $CONR^5R^6$  or  $CO_2R^7$ ;  $C_2$ - $C_4$  alkanoyl optionally substituted with  $NR^5R^6$ ; (hydroxy) $C_2$ - $C_4$  alkyl optionally substituted with  $NR^5R^6$ ; ( $C_2$ - $C_3$  alkoxy) $C_1$ - $C_2$  alkyl optionally substituted with OH or  $NR^5R^6$ ;  $CONR^5R^6$ ;  $CO_2R^7$ ; halo;  $NR^5R^6$ ;  $NHSO_2NR^5R^6$ ;  $NHSO_2R^8$ ;  $SO_2NR^9R^{10}$ ; or phenyl, pyridyl, pyrimidinyl, imidazolyl, oxazolyl, thiazolyl, thienyl or triazolyl any of which is optionally substituted with methyl;  
 $R^5$  and  $R^6$  are each independently H or  $C_1$ - $C_4$  alkyl, or together with the nitrogen atom to which they are attached form a pyrrolidinyl, piperidino, morpholino, 4- $N(R^{11})$ -piperazinyl or imidazolyl group wherein said group is optionally substituted with methyl or OH;

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R<sup>7</sup> is H or C<sub>1</sub>-C<sub>4</sub> alkyl;

R<sup>8</sup> is C<sub>1</sub>-C<sub>3</sub> alkyl optionally substituted with NR<sup>5</sup>R<sup>6</sup>;

R<sup>9</sup> and R<sup>10</sup> together with the nitrogen atom to which they are attached form a pyrrolidinyl, piperidino, morpholino or 4-N(R<sup>12</sup>)-piperazinyl group wherein said group is optionally substituted with C<sub>1</sub>-C<sub>4</sub> alkyl, C<sub>1</sub>-C<sub>3</sub> alkoxy, NR<sup>13</sup>R<sup>14</sup> or CONR<sup>13</sup>R<sup>14</sup>;

R<sup>11</sup> is H; C<sub>1</sub>-C<sub>3</sub> alkyl optionally substituted with phenyl; (hydroxy)C<sub>2</sub>-C<sub>3</sub> alkyl; or C<sub>1</sub>-C<sub>4</sub> alkanoyl;

R<sup>12</sup> is H; C<sub>1</sub>-C<sub>6</sub> alkyl; (C<sub>1</sub>-C<sub>3</sub> alkoxy)C<sub>2</sub>-C<sub>6</sub> alkyl; (hydroxy)C<sub>2</sub>-C<sub>6</sub> alkyl; (R<sup>13</sup>R<sup>14</sup>N)C<sub>2</sub>-C<sub>6</sub> alkyl; (R<sup>13</sup>R<sup>14</sup>NOC)C<sub>1</sub>-C<sub>6</sub> alkyl; CONR<sup>13</sup>R<sup>14</sup>; CSNR<sup>13</sup>R<sup>14</sup>; or C(NH)NR<sup>13</sup>R<sup>14</sup>;

and R<sup>13</sup> and R<sup>14</sup> are each independently H; C<sub>1</sub>-C<sub>4</sub> alkyl; (C<sub>1</sub>-C<sub>3</sub> alkoxy)C<sub>2</sub>-C<sub>4</sub> alkyl; or (hydroxy)C<sub>2</sub>-C<sub>4</sub> alkyl;

or a pharmaceutically acceptable salt thereof, or a pharmaceutical composition containing either entity, for the manufacture of a medicament for the curative or prophylactic treatment of erectile dysfunction in a male animal, including man.

In the above definition, unless otherwise indicated, alkyl groups having three or more carbon atoms, alkenyl and alkynyl groups having four or more carbon atoms, alkoxy groups having three carbon atoms and alkanoyl groups having four carbon atoms may be straight chain or branched chain. Halo means fluoro, chloro, bromo or iodo.

The compounds of formula (I) may contain one or more asymmetric centres and thus they can exist as enantiomers or diastereoisomers. Furthermore, certain compounds of formula (I) which contain alkenyl groups

may exist as cis-isomers or trans-isomers. In each instance, the invention includes both mixtures and separate individual isomers.

The compounds of formula (I) may also exist in tautomeric forms and the invention includes both mixtures and separate individual tautomers.

The pharmaceutically acceptable salts of the compounds of formula (I) which contain a basic centre are, for example, non-toxic acid addition salts formed with inorganic acids such as hydrochloric, hydrobromic, sulphuric and phosphoric acid, with organo-carboxylic acids, or with organo-sulphonic acids. Compounds of formula (I) can also provide pharmaceutically acceptable metal salts, in particular non-toxic alkali metal salts, with bases. Examples include the sodium and potassium salts.

A preferred group of compounds of formula (I) is that wherein  $R^1$  is H, methyl or ethyl;  $R^2$  is  $C_1$ - $C_3$  alkyl;  $R^3$  is  $C_2$ - $C_3$  alkyl or allyl;  $R^4$  is  $C_1$ - $C_2$  alkyl optionally substituted with OH,  $NR^5R^6$ , CN,  $CONR^5R^6$  or  $CO_2R^7$ ; acetyl optionally substituted with  $NR^5R^6$ ; hydroxyethyl optionally substituted with  $NR^5R^6$ ; ethoxymethyl optionally substituted with OH or  $NR^5R^6$ ;  $CH=CHCN$ ;  $CH=CHCONR^5R^6$ ;  $CH=CHCO_2R^7$ ;  $CONR^5R^6$ ;  $CO_2H$ ; Br;  $NR^5R^6$ ;  $NHSO_2NR^5R^6$ ;  $NHSO_2R^8$ ;  $SO_2NR^9R^{10}$ ; or pyridyl or imidazolyl either of which is optionally substituted with methyl;  $R^5$  and  $R^6$  are each independently H, methyl or ethyl, or together with the nitrogen atom to which they are attached form a piperidino, morpholino, 4-N( $R^{11}$ )-piperazinyl or imidazolyl group wherein said group is optionally substituted with methyl or OH;  $R^7$  is H or t-butyl;  $R^8$  is methyl or  $CH_2CH_2CH_2NR^5R^6$ ;  $R^9$  and  $R^{10}$  together with the nitrogen atom to which they are attached form a piperidino or 4-N( $R^{12}$ )-piperazinyl group wherein said group is optionally substituted with  $NR^{13}R^{14}$  or  $CONR^{13}R^{14}$ ;  $R^{11}$  is H, methyl, benzyl, 2-

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hydroxyethyl or acetyl;  $R^{12}$  is H,  $C_1-C_3$  alkyl, (hydroxy) $C_2-C_3$  alkyl,  $CSNR^{13}R^{14}$  or  $C(NH)NR^{13}R^{14}$ ; and  $R^{13}$  and  $R^{14}$  are each independently H or methyl.

A more preferred group of compounds of formula (I) is that wherein  $R^1$  is methyl or ethyl;  $R^2$  is  $C_1-C_3$  alkyl;  $R^3$  is ethyl, n-propyl or allyl;  $R^4$  is  $CH_2NR^5R^6$ ,  $COCH_2NR^5R^6$ ,  $CH(OH)CH_2NR^5R^6$ ,  $CH_2OCH_2CH_3$ ,  $CH_2OCH_2CH_2OH$ ,  $CH_2OCH_2CH_2NR^5R^6$ ,  $CH=CHCON(CH_3)_2$ ,  $CH=CHCO_2R^7$ ,  $CONR^5R^6$ ,  $CO_2H$ , Br,  $NHSO_2NR^5R^6$ ,  $NHSO_2CH_2CH_2CH_2NR^5R^6$ ,  $SO_2NR^9R^{10}$ , 2-pyridyl, 1-imidazolyl or 1-methyl-2-imidazolyl;  $R^5$  and  $R^6$  together with the nitrogen atom to which they are attached form a piperidino, 4-hydroxypiperidino, morpholino, 4-N( $R^{11}$ )-piperazinyl or 2-methyl-1-imidazolyl group;  $R^7$  is H or t-butyl;  $R^9$  and  $R^{10}$  together with the nitrogen atom to which they are attached form a 4-carbamoylpiperidino or 4-N( $R^{12}$ )-piperazinyl group;  $R^{11}$  is H, methyl, benzyl, 2-hydroxyethyl or acetyl; and  $R^{12}$  is H,  $C_1-C_3$  alkyl, 2-hydroxyethyl or  $CSNE_2$ .

A particularly preferred group of compounds of formula (I) is that wherein  $R^1$  is methyl or ethyl;  $R^2$  is n-propyl;  $R^3$  is ethyl, n-propyl or allyl;  $R^4$  is  $COCH_2NR^5R^6$ ,  $CONR^5R^6$ ,  $SO_2NR^9R^{10}$  or 1-methyl-2-imidazolyl;  $R^5$  and  $R^6$  together with the nitrogen atom to which they are attached form a morpholino or 4-N( $R^{11}$ )-piperazinyl group;  $R^9$  and  $R^{10}$  together with the nitrogen atom to which they are attached form a 4-N( $R^{12}$ )-piperazinyl group;  $R^{11}$  is methyl or acetyl; and  $R^{12}$  is H, methyl, 2-propyl or 2-hydroxyethyl.

Especially preferred individual compounds of the invention include:

5-(2-ethoxy-5-morpholinoacetylphenyl)-1-methyl-3-n-propyl-1,6-dihydro-7H-pyrazolo[4,3-d]pyrimidin-7-one;

5-(5-morpholinoacetyl-2-n-propoxyphenyl)-1-methyl-3-n-propyl-1,6-dihydro-7H-pyrazolo[4,3-d]pyrimidin-7-one;



5-[2-ethoxy-5-(4-methyl-1-piperazinylsulphonyl)-phenyl]-1-methyl-3-n-propyl-1,6-dihydro-7H-pyrazolo[4,3-d]pyrimidin-7-one;

5-[2-allyloxy-5-(4-methyl-1-piperazinylsulphonyl)-phenyl]-1-methyl-3-n-propyl-1,6-dihydro-7H-pyrazolo[4,3-d]pyrimidin-7-one;

5-{2-ethoxy-5-[4-(2-propyl)-1-piperazinylsulphonyl]phenyl}-1-methyl-3-n-propyl-1,6-dihydro-7H-pyrazolo[4,3-d]pyrimidin-7-one;

5-{2-ethoxy-5-[4-(2-hydroxyethyl)-1-piperazinylsulphonyl]phenyl}-1-methyl-3-n-propyl-1,6-dihydro-7H-pyrazolo[4,3-d]pyrimidin-7-one;

5-{5-[4-(2-hydroxyethyl)-1-piperazinylsulphonyl]-2-n-propoxyphenyl}-1-methyl-3-n-propyl-1,6-dihydro-7H-pyrazolo[4,3-d]pyrimidin-7-one;

5-[2-ethoxy-5-(4-methyl-1-piperazinylcarbonyl)-phenyl]-1-methyl-3-n-propyl-1,6-dihydro-7H-pyrazolo[4,3-d]pyrimidin-7-one;

and 5-[2-ethoxy-5-(1-methyl-2-imidazolyl)phenyl]-1-methyl-3-n-propyl-1,6-dihydro-7H-pyrazolo[4,3-d]pyrimidin-7-one.

The compounds of formula (I) and their pharmaceutically acceptable salts, processes for the preparation thereof, in vitro test methods for determining the cGMP PDE and cAMP PDE inhibitory activities thereof, pharmaceutical compositions thereof and routes of administration for human use, are described in EP-A-0463756 and EP-A-0526004.

A preliminary investigation was carried out with a view to isolating and characterising the cyclic nucleotide PDEs of human corpus cavernosum, relaxation of which leads to penile erection. Studies of substrate specificity, response to activators and inhibitor sensitivity, have demonstrated that human corpus cavernosum contains three distinct PDE enzymes.

### Methods

Fresh frozen human penis was obtained from IIAM (Pennsylvania). Tissue was thawed at room temperature, the corpus cavernosum was dissected from the penis to yield approximately 2-4 g of tissue and the following isolation protocol was followed. Tissue was coarsely chopped in ice-cold isotonic buffer (35 ml) containing 250mM sucrose, 1mM EDTA, 0.5mM PMSF and 20mM HEPES, pH 7.2, and the mixture subjected to brief (1 min.) treatment with a Silversen mixer/emulsifier. Homogenates were prepared using homogeniser tubes with teflon pestles and soluble fraction was prepared by centrifugation at 100,000 x g for 60 min. at 4°C. 10 ml of high speed supernatant was applied to a Pharmacia Mono Q anion exchange column (1 ml bed volume) equilibrated with buffer containing 1mM EDTA, 0.5 mM PMSF and 20mM HEPES, pH 7.2 (chromatography buffer). The column was then washed with 5 bed volumes of chromatography buffer, after which PDEs were eluted using a continuous gradient of 0-500mM NaCl (total volume 35 ml) and 1 ml fractions collected.

Column fractions were assayed for PDE activity using 500nM cGMP or 500nM cAMP as substrate. cAMP PDE activity was also determined in the presence of 1 $\mu$ M unlabelled cGMP and the PDE activity of selected fractions was determined in the presence of 10mM CaCl<sub>2</sub> and 10 units/ml bovine brain calmodulin. Appropriate fractions were pooled and stored at 4°C during the course of the study.

Inhibition studies were performed using a substrate concentration of 500nM throughout. All inhibitors were dissolved in DMSO and concentration-response curves were constructed over the range 3 x 10<sup>-10</sup> to 1 x 10<sup>-4</sup>M in half log increments. IC<sub>50</sub> values were calculated using the sigmoidal curve fitting algorithm of biostat.

### Results

Human corpus cavernosum soluble PDEs were separated into three distinct fractions of activity. The first, fraction I, (designated by order of elution) represents the major PDE present and is highly selective for cGMP as substrate. This fraction was found to be insensitive to stimulation by calcium/calmodulin and was classified as PDE<sub>v</sub>. Fraction II hydrolyses cGMP and cAMP, with the latter activity being stimulated in the presence of cGMP, and is classified as PDE<sub>II</sub>, whilst fraction III is cAMP selective and this activity is inhibited in the presence of cGMP, consistent with PDE<sub>III</sub> activity.

In order to further characterise the PDE isoenzymes present in the tissue, studies were performed using a variety of inhibitors. Inhibitor studies with fractions I and II were performed using cGMP as substrate, whilst fraction III studies utilised cAMP. These studies confirmed that fraction I corresponds to PDE<sub>v</sub>, whilst fraction III was clearly identified as PDE<sub>III</sub>; fraction II (PDE<sub>II</sub>) was relatively insensitive to all the inhibitors tested.

In summary, the above investigation identified three PDE isoenzymes in human corpus cavernosum tissue. The predominant PDE is the cGMP-specific PDE<sub>v</sub>, whilst cGMP-stimulated cAMP PDE<sub>II</sub> and cGMP-inhibited cAMP PDE<sub>III</sub> are also present.

The compounds of the invention have been tested in vitro and found to be potent and selective inhibitors of the cGMP-specific PDE<sub>v</sub>. For example, one of the especially preferred compounds of the invention has an  $IC_{50} = 6.8 \text{ nM}$  v. the PDE<sub>v</sub> enzyme, but demonstrates only weak inhibitory activity against the PDE<sub>II</sub> and PDE<sub>III</sub> enzymes with  $IC_{50} = >100 \text{ }\mu\text{M}$  and  $34 \text{ }\mu\text{M}$  respectively. Thus relaxation of the corpus cavernosum tissue and

consequent penile erection is presumably mediated by elevation of cGMP levels in the said tissue, by virtue of the PDE inhibitory profile of the compounds of the invention.

Furthermore, none of the compounds of the invention tested in rat and dog, both intravenously (i.v.) and orally (p.o.) at up to 3 mg/Kg, has shown any overt sign of adverse acute toxicity. In mouse, no deaths occurred after doses of up to 100 mg/Kg i.v.. Certain especially preferred compounds showed no toxic effects on chronic p.o. administration to rat at up to 10 mg/Kg and to dog at up to 20 mg/Kg.

In man, certain especially preferred compounds have been tested orally in both single dose and multiple dose volunteer studies. Moreover, patient studies conducted thus far have confirmed that one of the especially preferred compounds induces penile erection in impotent males.

Although the compounds of the invention are envisaged primarily for the treatment of erectile dysfunction or male sexual dysfunction, they may also be useful for the treatment of female sexual dysfunction including orgasmic dysfunction related to clitoral disturbances.

Generally, in man, oral administration of the compounds of the invention is the preferred route, being the most convenient and avoiding the disadvantages associated with i.c. administration. A preferred dosing regimen for a typical man is 5 to 75 mg of compound three times daily. In circumstances where the recipient suffers from a swallowing disorder or from impairment of drug absorption after oral administration, the drug may be administered parenterally, e.g. sublingually or buccally.

For veterinary use, a compound of formula (I) or a non-toxic salt thereof is administered as a suitably acceptable formulation in accordance with

normal veterinary practice and the veterinary surgeon will determine the dosing regimen and route of administration which will be most appropriate for a particular male animal.

Thus the invention includes a pharmaceutical composition for the curative or prophylactic treatment of erectile dysfunction in a male animal, including man, comprising a compound of formula (I), or a pharmaceutically acceptable salt thereof, together with a pharmaceutically acceptable diluent or carrier.

There is further provided a process for the preparation of a pharmaceutical composition for the curative or prophylactic treatment of erectile dysfunction in a male animal, including man, comprising formulating a compound of formula (I), or a pharmaceutically acceptable salt thereof, with a pharmaceutically acceptable diluent or carrier.

The invention also provides a method of treating a male animal, including man, to cure or prevent erectile dysfunction which comprises treating said male animal with an effective amount of a compound of formula (I), or a pharmaceutically acceptable salt thereof, or a pharmaceutical composition containing either entity.

In a further aspect, the invention includes the use of a cGMP PDE inhibitor, or a pharmaceutically acceptable salt thereof, or a pharmaceutical composition containing either entity, for the treatment of erectile dysfunction in a male animal, including man.

The invention also includes a method of treating a male animal, including man, to cure or prevent erectile dysfunction, which comprises treating said male animal with an effective amount of a cGMP PDE inhibitor, or a pharmaceutically acceptable salt thereof, or a pharmaceutical composition containing either entity.

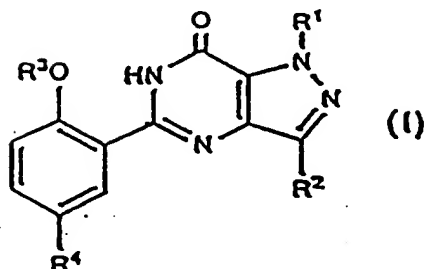
Moreover, the invention includes the use of a cGMP PDE inhibitor, or a pharmaceutically acceptable salt

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thereof, or a pharmaceutical composition containing either entity, for the manufacture of a medicament for the curative or prophylactic treatment of erectile dysfunction in a male animal, including man.

CLAIMS

1. The use of a compound of formula (I):



wherein  $R^1$  is H;  $C_1-C_3$  alkyl;  $C_1-C_3$  perfluoroalkyl; or  $C_3-C_5$  cycloalkyl;  
 $R^2$  is H;  $C_1-C_6$  alkyl optionally substituted with  $C_3-C_6$  cycloalkyl;  $C_1-C_3$  perfluoroalkyl; or  $C_3-C_6$  cycloalkyl;  
 $R^3$  is  $C_1-C_6$  alkyl optionally substituted with  $C_3-C_6$  cycloalkyl;  $C_1-C_6$  perfluoroalkyl;  $C_3-C_5$  cycloalkyl;  $C_3-C_6$  alkenyl; or  $C_3-C_6$  alkynyl;  
 $R^4$  is  $C_1-C_4$  alkyl optionally substituted with OH,  $NR^5R^6$ , CN,  $CONR^5R^6$  or  $CO_2R^7$ ;  $C_2-C_4$  alkenyl optionally substituted with CN,  $CONR^5R^6$  or  $CO_2R^7$ ;  $C_2-C_4$  alkanoyl optionally substituted with  $NR^5R^6$ ; (hydroxy) $C_2-C_4$  alkyl optionally substituted with  $NR^5R^6$ ; ( $C_2-C_3$  alkoxy) $C_1-C_2$  alkyl optionally substituted with OH or  $NR^5R^6$ ;  $CONR^5R^6$ ;  $CO_2R^7$ ; halo;  $NR^5R^6$ ;  $NHSO_2NR^5R^6$ ;  $NHSO_2R^8$ ;  $SO_2NR^9R^{10}$ ; or phenyl, pyridyl, pyrimidinyl, imidazolyl, oxazolyl, thiazolyl, thienyl or triazolyl any of which is optionally substituted with methyl;  
 $R^5$  and  $R^6$  are each independently H or  $C_1-C_4$  alkyl, or together with the nitrogen atom to which they are attached form a pyrrolidinyl, piperidino, morpholino, 4- $N(R^{11})$ -piperazinyl

or imidazolyl group wherein said group is optionally substituted with methyl or OH;  
 $R^7$  is H or  $C_1-C_4$  alkyl;

$R^8$  is  $C_1-C_3$  alkyl optionally substituted with  $NR^5R^6$ ;

$R^9$  and  $R^{10}$  together with the nitrogen atom to which they are attached form a pyrrolidinyl, piperidino, morpholino or 4- $N(R^{12})$ -piperazinyl group wherein said group is optionally substituted with  $C_1-C_4$  alkyl,  $C_1-C_3$  alkoxy,  $NR^{13}R^{14}$  or  $CONR^{13}R^{14}$ ;

$R^{11}$  is H;  $C_1-C_3$  alkyl optionally substituted with phenyl; (hydroxy) $C_2-C_3$  alkyl; or  $C_1-C_4$  alkanoyl;

$R^{12}$  is H;  $C_1-C_6$  alkyl; ( $C_1-C_3$  alkoxy) $C_2-C_6$  alkyl; (hydroxy) $C_2-C_6$  alkyl; ( $R^{13}R^{14}N$ ) $C_2-C_6$  alkyl; ( $R^{13}R^{14}NOC$ ) $C_1-C_6$  alkyl;  $CONR^{13}R^{14}$ ;  $CSNR^{13}R^{14}$ ; or  $C(NH)NR^{13}R^{14}$ ;

and  $R^{13}$  and  $R^{14}$  are each independently H;  $C_1-C_4$  alkyl; ( $C_1-C_3$  alkoxy) $C_2-C_4$  alkyl; or (hydroxy) $C_2-C_4$  alkyl;

or a pharmaceutically acceptable salt thereof, or a pharmaceutical composition containing either entity, for the manufacture of a medicament for the curative or prophylactic treatment of erectile dysfunction in a male animal, including man.

2. The use according to claim 1 wherein in the compound of formula (I)  $R^1$  is H, methyl or ethyl;  $R^2$  is  $C_1-C_3$  alkyl;  $R^3$  is  $C_2-C_3$  alkyl or allyl;  $R^4$  is  $C_1-C_2$  alkyl optionally substituted with OH,  $NR^5R^6$ , CN,  $CONR^5R^6$  or  $CO_2R^7$ ; acetyl optionally substituted with  $NR^5R^6$ ; hydroxyethyl optionally substituted with  $NR^5R^6$ ; ethoxymethyl optionally substituted with OH or  $NR^5R^6$ ;  $CH=CHCN$ ;  $CH=CHCONR^5R^6$ ;  $CH=CHCO_2R^7$ ;  $CONR^5R^6$ ;  $CO_2H$ ; Br;  $NR^5R^6$ ;  $NHSO_2NR^5R^6$ ;  $NHSO_2R^8$ ;  $SO_2NR^9R^{10}$ ; or pyridyl or



imidazolyl either of which is optionally substituted with methyl;  $R^5$  and  $R^6$  are each independently H, methyl or ethyl, or together with the nitrogen atom to which they are attached form a piperidino, morpholino, 4-N( $R^{11}$ )-piperazinyl or imidazolyl group wherein said group is optionally substituted with methyl or OH;  $R^7$  is H or t-butyl;  $R^8$  is methyl or  $\text{CH}_2\text{CH}_2\text{CH}_2\text{NR}^5\text{R}^6$ ;  $R^9$  and  $R^{10}$  together with the nitrogen atom to which they are attached form a piperidino or 4-N( $R^{12}$ )-piperazinyl group wherein said group is optionally substituted with  $\text{NR}^{13}\text{R}^{14}$  or  $\text{CONR}^{13}\text{R}^{14}$ ;  $R^{11}$  is H, methyl, benzyl, 2-hydroxyethyl or acetyl;  $R^{12}$  is H,  $\text{C}_1\text{-C}_3$  alkyl, (hydroxy) $\text{C}_2\text{-C}_3$  alkyl,  $\text{CSNR}^{13}\text{R}^{14}$  or  $\text{C}(\text{NH})\text{NR}^{13}\text{R}^{14}$ ; and  $R^{13}$  and  $R^{14}$  are each independently H or methyl.

3. The use according to claim 2 wherein in the compound of formula (I)  $R^1$  is methyl or ethyl;  $R^2$  is  $\text{C}_1\text{-C}_3$  alkyl;  $R^3$  is ethyl, n-propyl or allyl;  $R^4$  is  $\text{CH}_2\text{NR}^5\text{R}^6$ ,  $\text{COCH}_2\text{NR}^5\text{R}^6$ ,  $\text{CH}(\text{OH})\text{CH}_2\text{NR}^5\text{R}^6$ ,  $\text{CH}_2\text{OCH}_2\text{CH}_3$ ,  $\text{CH}_2\text{OCH}_2\text{CH}_2\text{OH}$ ,  $\text{CH}_2\text{OCH}_2\text{CH}_2\text{NR}^5\text{R}^6$ ,  $\text{CH}=\text{CHCON}(\text{CH}_3)_2$ ,  $\text{CH}=\text{CHCO}_2\text{R}^7$ ,  $\text{CONR}^5\text{R}^6$ ,  $\text{CO}_2\text{H}$ , Br,  $\text{NHSO}_2\text{NR}^5\text{R}^6$ ,  $\text{NHSO}_2\text{CH}_2\text{CH}_2\text{CH}_2\text{NR}^5\text{R}^6$ ,  $\text{SO}_2\text{NR}^9\text{R}^{10}$ , 2-pyridyl, 1-imidazolyl or 1-methyl-2-imidazolyl;  $R^5$  and  $R^6$  together with the nitrogen atom to which they are attached form a piperidino, 4-hydroxypiperidino, morpholino, 4-N( $R^{11}$ )-piperazinyl or 2-methyl-1-imidazolyl group;  $R^7$  is H or t-butyl;  $R^9$  and  $R^{10}$  together with the nitrogen atom to which they are attached form a 4-carbamoylpiperidino or 4-N( $R^{12}$ )-piperazinyl group;  $R^{11}$  is H, methyl, benzyl, 2-hydroxyethyl or acetyl; and  $R^{12}$  is H,  $\text{C}_1\text{-C}_3$  alkyl, 2-hydroxyethyl or  $\text{CSNH}_2$ .

4. The use according to claim 3 wherein in the compound of formula (I)  $R^1$  is methyl or ethyl;  $R^2$  is n-propyl;  $R^3$  is ethyl, n-propyl or allyl;  $R^4$  is  $\text{COCH}_2\text{NR}^5\text{R}^6$ ,  $\text{CONR}^5\text{R}^6$ ,  $\text{SO}_2\text{NR}^9\text{R}^{10}$  or 1-methyl-2-imidazolyl;  $R^5$  and  $R^6$  together with the nitrogen atom to which they are attached form a morpholino or 4-N( $R^{11}$ )-piperazinyl

group; R<sup>9</sup> and R<sup>10</sup> together with the nitrogen atom to which they are attached form a 4-N(R<sup>12</sup>)-piperazinyl group; R<sup>11</sup> is methyl or acetyl; and R<sup>12</sup> is H, methyl, 2-propyl or 2-hydroxyethyl.

5. The use according to claim 4 wherein the compound of formula (I) is selected from:

5-(2-ethoxy-5-morpholinoacetylphenyl)-1-methyl-3-n-propyl-1,6-dihydro-7H-pyrazolo[4,3-d]pyrimidin-7-one;

5-(5-morpholinoacetyl-2-n-propoxyphenyl)-1-methyl-3-n-propyl-1,6-dihydro-7H-pyrazolo[4,3-d]pyrimidin-7-one;

5-[2-ethoxy-5-(4-methyl-1-piperazinylsulphonyl)-phenyl]-1-methyl-3-n-propyl-1,6-dihydro-7H-pyrazolo[4,3-d]pyrimidin-7-one;

5-[2-allyloxy-5-(4-methyl-1-piperazinylsulphonyl)-phenyl]-1-methyl-3-n-propyl-1,6-dihydro-7H-pyrazolo[4,3-d]pyrimidin-7-one;

5-{2-ethoxy-5-[4-(2-propyl)-1-piperazinylsulphonyl]phenyl}-1-methyl-3-n-propyl-1,6-dihydro-7H-pyrazolo[4,3-d]pyrimidin-7-one;

5-{2-ethoxy-5-[4-(2-hydroxyethyl)-1-piperazinylsulphonyl]phenyl}-1-methyl-3-n-propyl-1,6-dihydro-7H-pyrazolo[4,3-d]pyrimidin-7-one;

5-{5-[4-(2-hydroxyethyl)-1-piperazinylsulphonyl]-2-n-propoxyphenyl}-1-methyl-3-n-propyl-1,6-dihydro-7H-pyrazolo[4,3-d]pyrimidin-7-one;

5-[2-ethoxy-5-(4-methyl-1-piperazinylcarbonyl)-phenyl]-1-methyl-3-n-propyl-1,6-dihydro-7H-pyrazolo[4,3-d]pyrimidin-7-one;

and 5-[2-ethoxy-5-(1-methyl-2-imidazolyl)phenyl]-1-methyl-3-n-propyl-1,6-dihydro-7H-pyrazolo[4,3-d]pyrimidin-7-one.

6. A pharmaceutical composition for the curative or prophylactic treatment of erectile dysfunction in a male animal, including man, comprising a compound of formula (I) according to any one of claims 1 to 5, or a pharmaceutically acceptable salt thereof, together

with a pharmaceutically acceptable diluent or carrier.

7. A process for the preparation of a pharmaceutical composition for the curative or prophylactic treatment of erectile dysfunction in a male animal, including man, comprising formulating a compound of formula (I) according to any one of claims 1 to 5, or a pharmaceutically acceptable salt thereof, with a pharmaceutically acceptable diluent or carrier.

8. A method of treating a male animal, including man, to cure or prevent erectile dysfunction which comprises treating said male animal with an effective amount of a compound of formula (I) according to any one of claims 1 to 5, or a pharmaceutically acceptable salt thereof, or a pharmaceutical composition containing either entity.

9. The use of a cGMP PDE inhibitor, or a pharmaceutically acceptable salt thereof, or a pharmaceutical composition containing either entity, for the treatment of erectile dysfunction in a male animal, including man.

10. A method of treating a male animal, including man, to cure or prevent erectile dysfunction, which comprises treating said male animal with an effective amount of a cGMP PDE inhibitor, or a pharmaceutically acceptable salt thereof, or a pharmaceutical composition containing either entity.

11. The use of a cGMP PDE inhibitor, or a pharmaceutically acceptable salt thereof, or a pharmaceutical composition containing either entity, for the manufacture of a medicament for the curative or prophylactic treatment of erectile dysfunction in a male animal, including man.

## INTERNATIONAL SEARCH REPORT

International Application No

PCT/EP 94/01580

A. CLASSIFICATION OF SUBJECT MATTER  
IPC 5 A61K31/505

According to International Patent Classification (IPC) or to both national classification and IPC

## B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 5 A61K

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

| Category * | Citation of document, with indication, where appropriate, of the relevant passages   | Relevant to claim No. |
|------------|--|-----------------------|
| X          | EP,A,0 463 756 (PFIZER INC.) 2 January 1992<br>cited in the application<br>see claims 1-9<br>---   | 6,7                   |
| X          | EP,A,0 526 004 (PFIZER INC.) 3 February 1993<br>cited in the application<br>see claims 1-8<br>---  | 6,7                   |
| X          | BR. J. PHARMAC.<br>vol. 81, no. 4, 1984<br>pages 665 - 674<br>A. BOWMANN ET AL. 'Cyclic GMP mediates<br>neurogenic relaxation in the bovine<br>retractor penis muscle'<br>Y see page 670 - page 672<br>--- | 9-11                  |
|            | ---<br>-/--  | 1-5,8                 |

☒ Further documents are listed in the continuation of box C.☒ Patent family members are listed in annex.

## \* Special categories of cited documents :

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"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search

31 August 1994

Date of mailing of the international search report

13.09.94

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# INTERNATIONAL SEARCH REPORT

International Application No

PCT/EP 94/01580

## C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

| Category * | Citation of document, with indication, where appropriate, of the relevant passages   | Relevant to claim No. |
|------------|--|-----------------------|
| X          | AM. J. PHYSIOL.<br>vol. 264 , February 1993<br>pages H419 - H422<br>F. TRIGO-ROCHA ET AL. 'Nitric oxide and<br>cGMP: mediators of pelvic nerve-stimulated<br>erection in dogs' | 9-11                  |
| Y          | see page H419<br>see page H422<br>-----  | 1-5,8                 |

| Patent document<br>cited in search report | Publication<br>date | Patent family<br>member(s) | Publication<br>date |
|---|---------------------|----------------------------|---------------------|
| EP-A-0463756                              | 02-01-92            | AU-B- 626757               | 06-08-92            |
|   |                     | AU-A- 7915591              | 19-03-92            |
|   |                     | CN-A- 1057464              | 01-01-92            |
|   |                     | JP-A- 6041133              | 15-02-94            |
|   |                     | KR-B- 9406628              | 23-07-94            |
|   |                     | US-A- 5250534              | 05-10-93            |
| -----                                     |                     |                            |                     |
| EP-A-0526004                              | 03-02-93            | AU-B- 636816               | 06-05-93            |
|   |                     | AU-A- 1954592              | 11-03-93            |
|   |                     | CN-A- 1068329              | 27-01-93            |
|   |                     | JP-A- 5202050              | 10-08-93            |
|   |                     | NZ-A- 243472               | 23-12-93            |
|   |                     | US-A- 5272147              | 21-12-93            |
| -----                                     |                     |                            |                     |